Powered vs manual tooth brushing in patients with fixed orthodontic appliances

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Powered vs. manual tooth brushing in patients with fixed orthodontic appliances: a systematic review and meta-analysis

ABSTRACT

Objective: To compare powered and manual toothbrushes for oral hygiene maintenance in orthodontic patients.

Methods: Electronic databases including MEDLINE, Scopus, Google scholar, PubMed, Web of Science, the Cochrane Oral Health Group's Trials Register, and CENTRAL, were searched without language restrictions. Randomized clinical trials directly comparing manual and powered toothbrushing including patients with fixed orthodontic appliances reporting predefined outcomes with a follow-up period of at least four weeks were included. Using predefined data extraction forms, two authors independently undertook data extraction with conflict resolution by the third author. Quality assessment was based on the Cochrane Risk of Bias tool and overall evidence base was assessed using the GRADE system. A random effects meta-analysis combined the treatment effects across studies.

Results: Five trials were considered appropriate for inclusion in the meta-analysis with 8 trials excluded. There are slight differences in plaque index reduction of 0.05 (-0.04, 0.13) and 0.11 (-0.10, 0.33) at 4 week and 8 week follow-up respectively favoring manual toothbrushing but this was not statistically significant. There are slight differences in gingival index reduction of -0.02 (-0.06, 0.02) and -0.01 (-0.05, 0.02) at 4 week and 8 week follow-up respectively favoring powered brushing but again this was not statistically significant. The overall quality of evidence was very low to moderate for the primary outcomes.

Conclusion: Using manual or powered tooth brushing with fixed orthodontic appliances does not reduce plaque or gingival indices at 4 weeks and 8 weeks. This conclusion is however based on low quality of evidence from few studies. Greater standardization of the methodology used is desirable in future trials to increase our confidence in these findings.

INTRODUCTION

The placement of fixed appliances not only encourages biofilm formation but also raises the level of acidogenic bacteria inside the biofilm[1]. If patients do not maintain good oral hygiene during orthodontic treatment, the dental biofilm will produce acids that lead to enamel demineralization and white spot lesions around the orthodontic appliance. Development of the biofilm is also related to the presence of gingivitis and the greater the accumulation, the higher the gingival bleeding index[2,3]. Due to the unpredictable nature of periodontal disease progression, orthodontic patients with gingivitis must be considered to be at risk of periodontal damage[4].

The presence of fixed orthodontic appliances also modifies the microbial environment increasing the proliferation of the facultative bacterial population. Orthodontic treatment can therefore affect periodontial health, compromising oral health in general [5,6]. Direct damage to the periodontium as a result of excessively extended orthodontic bands can lead to loss of attachment causing gingival recession[7].

Clinically observed effects after placement of orthodontic appliances include inflammatory hyperplasia, gingival recession, and irreversible loss of attachment. These local factors further lead to biofilm accumulation and increase the risks of related problems during orthodontic treatment. The best way to avoid these deleterious effects is to prevent or control biofilm buildup[8]. Maintaining good oral hygiene by toothbrushing is the main factor during this process and regular toothbrushing, independent of educational level, or social status, is a significant factor in oral health[9,10]. Effective toothbrushing depends on several factors including motivation, knowledge and manual dexterity[11].

Powered toothbrushes were first introduced commercially in the early 1960s and have become established as an alternative to manual toothbrushing[12]. There are

many factors affecting the effectiveness of powered toothbrushing, from brush filament type and filament shape, size, orientation, and flexibility to the brush head size and shape, and the presence or absence of a timer. As well as the rotational motion or oscillation of the brush head, newer powered brushes have multi-motion actions that can also move in and out towards the tooth surface. Finally, battery type and duration influences brushing efficiency. All of these factors are important and must be kept in mind when selecting or assessing a powered toothbrush.

This systematic review aims to compare manual and powered toothbrushing during fixed orthodontic appliance treatment with regards to the removal of plaque, the health of the gingivae, and patient experience.

MATERIALS AND METHODS

The PRISMA guidelines were followed for this systematic review and meta-analysis.[13,14] The eligibility criteria (PICOT) for this systematic review were as follows:

Population: patients undergoing fixed appliance orthodontic treatment.

Intervention: manual toothbrushing as a method of plaque control

Comparison: powered toothbrushing as a method of plaque control.

Outcomes: plaque and / or gingival indices, patient compliance and patient experience.

Type of study: prospective randomized clinical trials (RCTs).

The following detailed selection criteria were applied for the review:

1) Types of participants: we included individuals wearing fixed orthodontic appliances, of any age with no reported disability that might affect toothbrushing ability.

2) Types of interventions: included in the review were all types of manual and powered toothbrushes. Trials where participants were permitted to continue with their usual adjuncts to oral hygiene, such as flossing, were included. Trials of 28

days (four weeks) and over were eligible and a subgroup analysis was carried out on the duration of intervention for the different outcome measures.

3) Types of outcome measures: The primary outcome measures used plaque and/or gingival indices. Secondary outcome measures were patient compliance and/or experience.

4) Types of studies: this review is confined to randomized controlled trials comparing manual and powered toothbrushes during fixed orthodontic treatment. It excludes trials only comparing different powered toothbrushes or those only comparing different manual toothbrushes.

Exclusion criteria

Cross-over and split mouth trials were excluded. With cross-over trials there may be carry-over effects for the different toothbrushes on gingivitis due to the short time between the measurements. Split-mouth trials were not considered an appropriate design as they were not representative of ’everyday use’, the effect of change of participant hand-use and the risk of crossover effects.

Studies were included irrespective of publication status or language as long as they could be translated. Toothbrushing studies where the toothbrushing was combined with the use of mouth rinse or irrigation as part of the study intervention was excluded due to the risk of confounding.

Electronic database search

Data sources were the electronic databases MEDLINE, Scopus, Google scholar, PubMed, Web of Science, the Cochrane Oral Health Group's Trials Register, and CENTRAL, without language restrictions. Unpublished trials were searched for on www.ClinicalTrials.gov, the National Research Register, and Pro-Quest Dissertation Abstracts and Thesis database. Reference lists of the included studies were manually searched for any additional relevant publications. Authors were contacted when necessary for further information. Search terms for Medline via EBSCO were ((MESH “Orthodontics+” OR ‘’plaque control’’ OR “manual brushing”) AND MH “powered brushing+” AND (“Plaque index” OR MH “gingival

index+" OR "Patient experience")). The search was initially run in April 2017 and updated in December 2018 and December 2019.

Using predefined data extraction forms, two authors (M.E, B.M) independently undertook data extraction with any conflict resolution by a third author when necessary. Randomized clinical trial quality assessment was based on the Cochrane Risk of Bias tool. Trial quality was evaluated by assessing the domains of random sequence generation, allocation concealment, blinding of participants and personnel, blinding of assessors, incomplete outcome data, selective reporting of outcomes, and other potential sources of bias. Meta-analysis was planned to obtain a better understanding of the intervention effect. Mean difference and 95% confidence interval were calculated to express the comparative treatment effect. A random effects model meta-analysis was undertaken using RevMan software to combine treatment effects across studies for each outcome.[15]

Data Extraction Process

The following information and details were extracted from each article, and transferred to customized data extraction forms: title, author name, author email and address, trial design, setting, funding source, sequence generation, allocation sequence concealment, blinding of participants and personnel, outcome assessor blinding, inclusion and exclusion criteria, total study duration, number of participants, age, sex, sample size calculation, type of treatment, intervention, comparisons, measurement tools or methods used, validity of methods, statistical analysis, outcomes (primary and secondary), results and notes. Data extracted is summarized in the Characteristic of Included Studies table (Table 1).

Risk of bias and quality of evidence assessment

Seven criteria as above were analyzed to assess the risk of bias inherent in each study. An overall assessment of risk of bias (high, unclear, low) was made for each included trial [16]. Studies with at least one criterion designated to be at high

risk of bias were regarded as having overall high risk of bias and were thus excluded from inclusion in the meta-analysis.

Statistical analysis

The estimation of effect calculated was the mean difference (MD) and 95% confidence intervals (CI) and was undertaken in RevMan5.0.[15] We assessed heterogeneity by review of a graphical display of the estimated treatment effects from the trials along with their 95% CI and by Cochran's test for heterogeneity[16]. The heterogeneity was quantified using the I^2 statistic and interpreted according to in the Cochrane Handbook for Systematic Reviews of Interventions.[16] The data was pooled for meta-analysis from the studies that shared the same measurement tool and unit of measurement and the same period of observation. The certainty in the evidence and of the recommendations was rated using the GRADEpro GDT.

RESULTS

After the initial searching 350 studies were identified. The Cochrane register identified 58 studies, Scopus 70, PubMed 77, Medline 65, and Web of Science 75, in addition to five identified by manual searching of reference lists. All the identified studies were entered into Endnote[17] to remove duplicated articles and sort the relevant and non-relevant studies. After removal of duplicated studies 100 studies remained. All of these remaining articles were screened by title and abstract which resulted in 77 non- relevant articles being removed, with the reasons for exclusion being not an RCT, incorrect interventions, incorrect type of participants, or less than 4 weeks follow-up. This left 23 included studies for which the full text articles were obtained. Fifteen of these were then excluded again because they did not meet the eligibility criteria and one article was excluded due to language with no translation being obtainable. Seven studies fulfilled the eligibility criteria to be included. Of the seven included studies, five contained data that were suitable for inclusion in the meta-analysis. A PRISMA flow diagram is shown in Figure 1.

Risk of bias assessment of candidate included studies is summarized in Figure 2. For the randomization sequence there is unclear method of randomization sequence generation in three studies[18-20] as these studies report that there is randomization but do not adequately describe the method of randomization. Two authors responded to requests for further information after contact and gave further details but the third did not respond. For allocation concealment, there are three studies which have an unclear method of concealment[18,21,22]. There is one study at high risk where there was no information about concealment[19]. For blinding, it was not possible to blind the participants except in one study (Pucher et al, 2011) that attempted blinding the type of powered brush by using it with an inactive battery with no vibration, but it was unclear if this method gave real blinding to the participants or not[20]. Two more studies did not mention the exact method of blinding[18,23] but the trial researcher was blinded to the group allocation throughout the trial period and so the studies were considered to be low risk of bias[1,21]. Two studies were at high risk of bias in blinding as these studies did not report that there was any blinding[19,22]. For incomplete outcome data (attrition bias), all the studies were well written with clear results, except one study that had eight out of 60 subjects drop out and it was unclear as to which group the drop-outs came from[20].

Data Synthesis

The following meta analyses were performed on the primary outcomes:

1) Comparison between powered and manual toothbrushing at 4 weeks follow up assessed by modified-orthodontic-plaque index is shown in Figure 3.

2) Comparison between powered and manual toothbrushing at 8 weeks follow up assessed by modified-orthodontic-plaque index is shown in Figure 4.

3) Comparison between powered and manual toothbrushing at 4 weeks follow up assessed by Plaque index is shown in Figure 5.

4) Comparison between powered and manual toothbrushing at 4 weeks follow up assessed by gingival index is shown in Figure 6.

5) Comparison between powered and manual toothbrushing at 8 weeks follow up assessed by gingival index is shown in Figure 7.

For Biavati et al.[18] we combined the result of two different groups of powered toothbrushes to standardize data entered into the meta-analysis using a statistical website (https://www.statstodo.com/CombineMeansSDs_Pgm.php).

The method used to combine means of two separate groups was as follows:

1. Calculate mean of each group

Combining the mean values by the formula:

$$x_c = \frac{m \cdot x_a + n \cdot x_b}{m + n}$$

Where:

x_a = the mean of the first set,
m = the number of items in the first set,
x_b = the mean of the second set,
n = the number of items in the second set,
x_c the combined mean.

GRADE Rating

The GRADEPro GDT was used to rate certainty in the findings and the result is shown in Table 2. Findings related to modified orthodontic plaque index and plaque index were graded as Low and Very Low, meaning that further research is likely to have an impact on these findings and so recommendations can only be conditional and only weak recommendations made. More studies reported on gingival index and the pooled effect from the meta-analysis showed good precision and at 8 weeks low inconsistency as demonstrated by the low heterogeneity in the meta-analysis. However, several of the studies included were at risk of bias so the GRADE ratings were low and moderate for 4 and 8 weeks respectively.

DISCUSSION

Toothbrushing is an important procedure to maintain oral hygiene and so gingival and periodontal health during orthodontic treatment. The selection of

toothbrushing method will depend on personal preference, affordability, availability, and professional recommendation. There is strong evidence that toothbrushing with fluoride toothpaste decreases gingivitis, periodontitis and tooth decay[12], but powered toothbrushes may have a specific appeal to some because they represent a 'high technology' solution for daily use.

Plaque Index

There are slight differences in modified-orthodontic-plaque index reduction of 0.05 (-0.04 , 0.13) and 0.11 (-0.10 ,0.33) at 4 week and 8 week follow-up favoring manual toothbrushing, based on two trials. There was a total of 68 participants in the manual toothbrushing group, and 71 in the powered toothbrushing group with approximately equal weighting of the two studies (48% and 52%)[1,21]. These differences were not statistically significant (Figure 3, 4). There was a slight difference in plaque index reduction of -0.12 (-0.37, 0.13) at 4 weeks favoring powered brushing (Figure 5) but again this difference was not statistically significant. This may be explained by patients relying on the powered brush motion and so making less effort by hand of the size and shape fo the powered head making access around fixed appliances more difficult.

Gingival Index

There are slight differences in gingival index with a reduction of -0.02 (-0.06, 0.02) and -0.01 (-0.05, 0.02) at 4 week and 8 week follow-up favoring powered brushing, based on 5 trials. These differences were however not statistically significant (Figure 6, 7)[1, 18, 19, 21, 22]. At 4 week follow up the total participants in powered and manual tooth brushing groups were 146 and 129 respectively and for 8 week follow up the total participants were 118 and 101 respectively. This difference is because one of the studies is not included in the meta-analysis of 8 week follow up[19].

Patient compliance and experience:

None of the included studies included patient compliance and/or experience as an outcome measure. We would strongly recommend these to be included in future studies of toothbrushing as they are very important factors in understanding the differences or lack of differences in the objective oral health outcomes. Patient experience can easily affect the use of either powered or manual toothbrush, which will directly affect the outcomes.

Limitations of this review

The results of this review should be interpreted with caution since there were few studies for each comparison, and the GRADE analysis rated the evidence for the findings between very low and moderate. Our search was restricted to English language and translated studies which may have reduced the number of studies included. However, a strength of the review is that it includes only randomized trials. Five of these trials were assessed as at low risk of bias (71.5%), two trials (28.5%) at unclear risk of bias, while no studies were assessed as at high risk of bias (0%). These trials were unable to demonstrate statistically significant differences between powered and manual toothbrushes in patients with fixed orthodontic appliances.

There was considerable heterogeneity in the meta-analyses for plaque scores of powered toothbrushes versus manual toothbrushes with the modified-orthodontic-plaque index. This heterogeneity could not be explained but may be because of use of the modified-orthodontic-plaque index or the small number of included studies.

One issue worth attention is the range of different measurement tools (indices) used in the studies, which meant less data could be pooled and included in the meta-analyses. A more standardized approach to assessing plaque and gingival health in this type of study would increase the ability to combine data in future studies so increasing our confidence in the conclusions.

All studies focused on short-term effects with the maximum follow-up being 8 weeks. Orthodontic treatment typically takes up to two years to complete and for

studies to have validity in this context then a longer duration of observation would be beneficial.

Clinical relevance

The effectiveness of powered toothbrushes in removing plaque and reducing gingivitis in patients with fixed orthodontic appliances can be related to destructive periodontal disease (periodontitis), which is related to oral hygiene.[4]

We conclude that there is no difference between manual and powered toothbrushes in reducing plaque accumulation or gingivitis in patients with fixed orthodontic appliances, however a Cochrane systematic review[24] of the same topic in non-orthodontic patients concluded that powered toothbrushes reduce plaque and gingivitis more than manual tooth brushing in both the short and long term. The possible explanation for this difference is the extra plaque retentive effect of the fixed appliances that may negate the advantage of powered brushing in non-orthodontic patients where smooth surface cleaning can be more effective. In addition, there were fewer trials on orthodontic patients to include in this review than in the non-orthodontic Cochrane systematic review and further trials are indicated on orthodontic patients to increase our certainty in the findings.

The clinical importance of our finding directly affects patients and orthodontists, as on the current evidence we can now advise orthodontic patients to use either of these toothbrushing approaches and leave the decision to them based on their personal preference which may enhance compliance. Few or no data were reported on the costs or reliability of the toothbrushes or the side effects of their use such as injuries to the gingivae.

RECOMMENDATIONS

1) Further studies need to be undertaken including patient experience and patient compliance of both types of toothbrushing.

2) The methods of sample generation, randomization and concealment were poorly reported which affect the validity and reliability of the results and the

confidence in the findings. Authors should follow the CONSORT Statement in reporting RCTs.

3) Different measurement methods (different indices for evaluation) were used in the studies so these should be standardized to allow pooling of the results.

CONCLUSIONS:

1. There is no difference between manual or powered toothbrushing in fixed orthodontic patients in plaque indices or gingival index at 4 week and 8 week follow up.
2. There is a need for well-designed RCTs to compare short and long term effects between manual and powered toothbrushes to increase our confidence in these findings which is very low to moderate.
3. Standardized indices to evaluate plaque and gingivitis for orthodontic patients should be agreed.
4. Patient experience and compliance with both toothbrushes should be included as an outcome measure in future RCTs.
5. Future studies should also include the potential factors that may affect the clinical choices such as age, health status, education level, and financial factors.

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Figure legend:

Figure 1: PRISMA flow diagram

Figure 2: Risk of bias summary

Figure 3: Forest plot of pooled mean difference between powered and manual tooth brushing in modified orthodontic plaque index reduction at 4 weeks

Figure 4: Forest plot of pooled mean difference between powered and manual tooth brushing in modified orthodontic plaque index reduction at 8 weeks

Figure 5: Forest plot of pooled mean difference between powered and manual tooth brushing in plaque index reduction

Figure 6: Forest plot of pooled mean difference between powered and manual tooth brushing in gingival index reduction at 4 weeks

Figure 7: Forest plot of pooled mean difference between powered and manual tooth brushing in gingival index reduction at 8 weeks